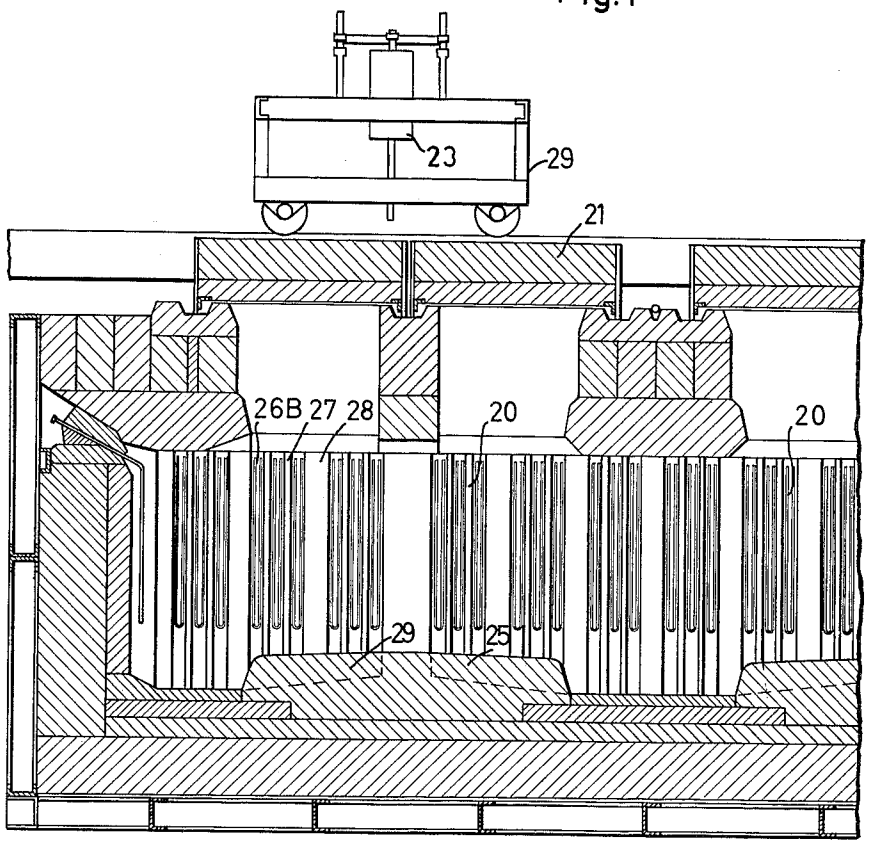
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ELECTRIC RESISTANCE FURNACES AND THE LIKE

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Fig.1



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By [signature]

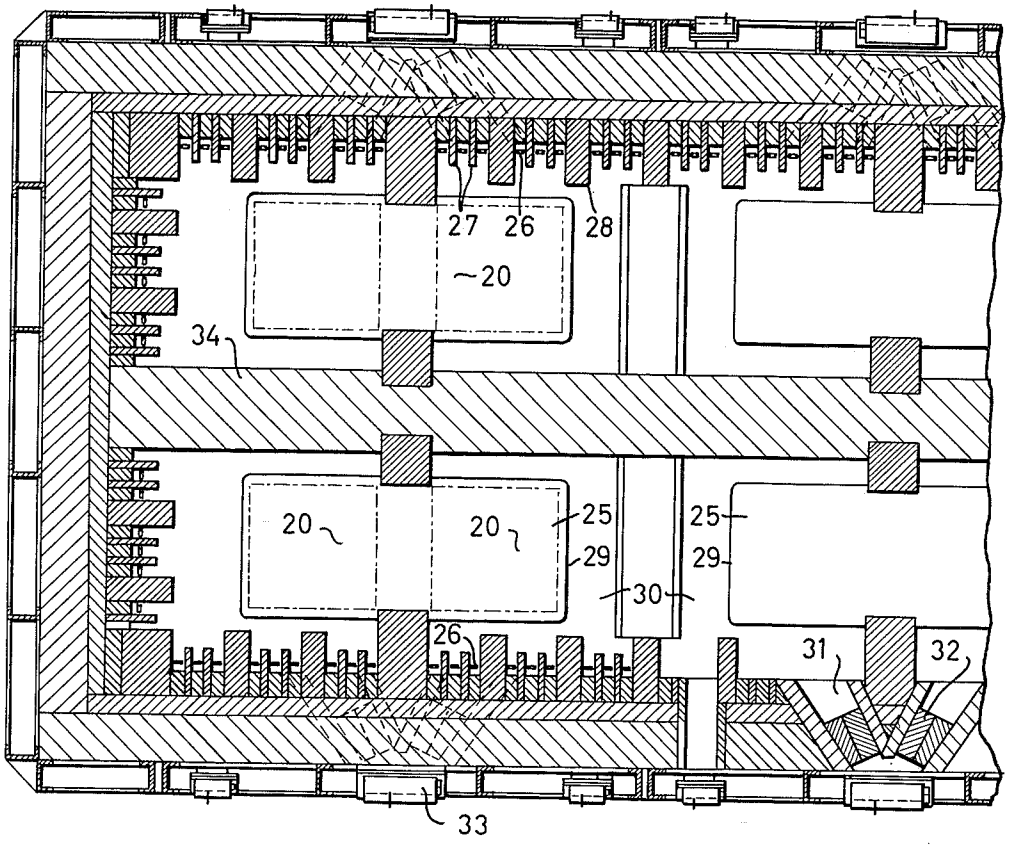
Attorney

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ELECTRIC RESISTANCE FURNACES AND THE LIKE

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Fig. 2



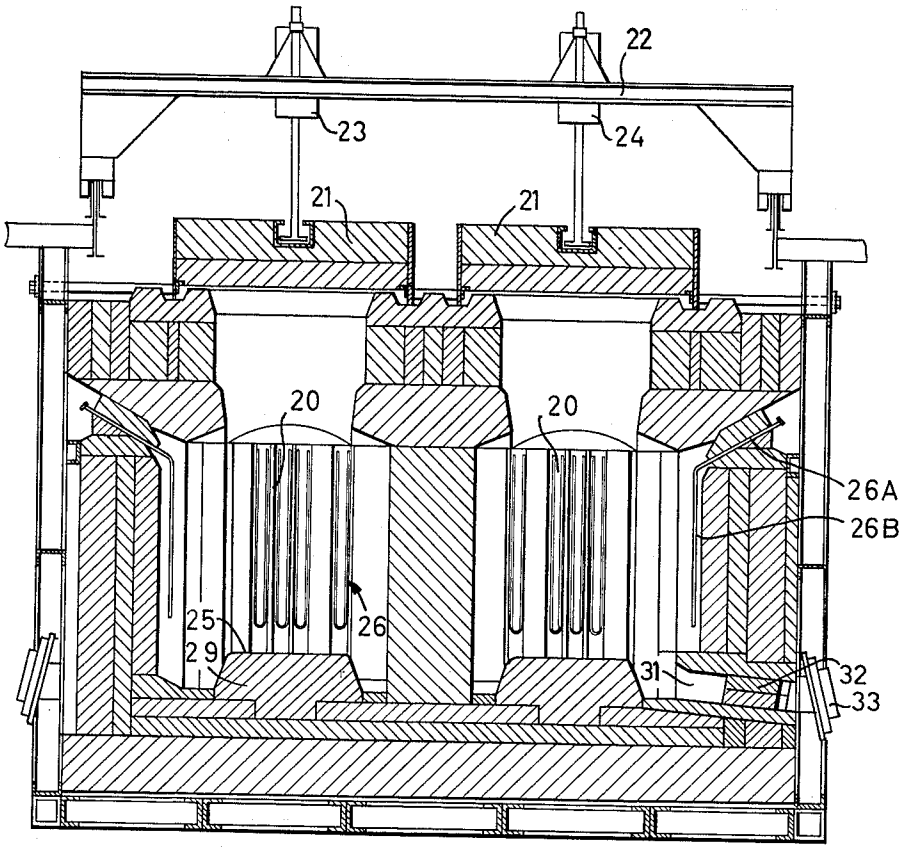
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ELECTRIC RESISTANCE FURNACES AND THE LIKE

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Fig. 3



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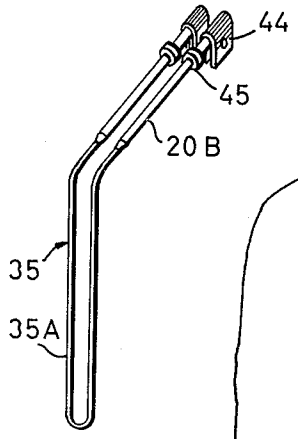


Fig. 6

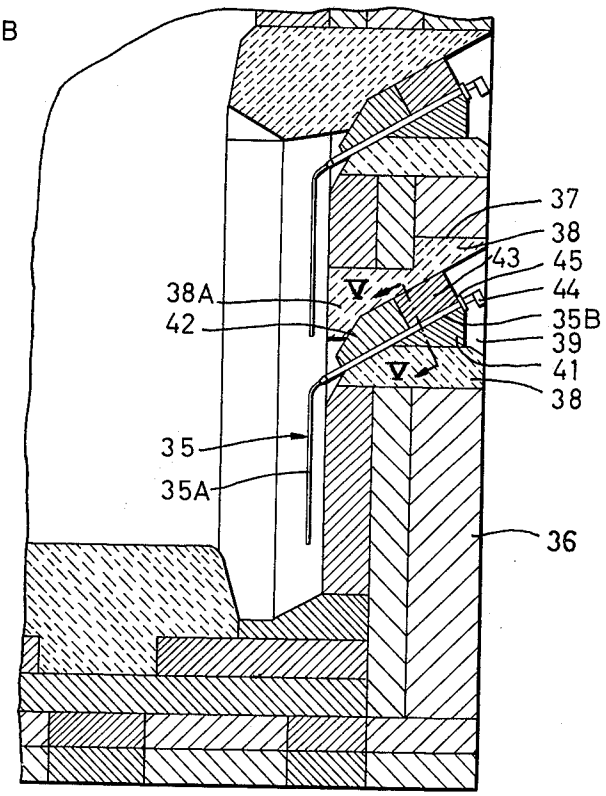


Fig. 4

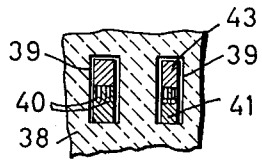


Fig. 5

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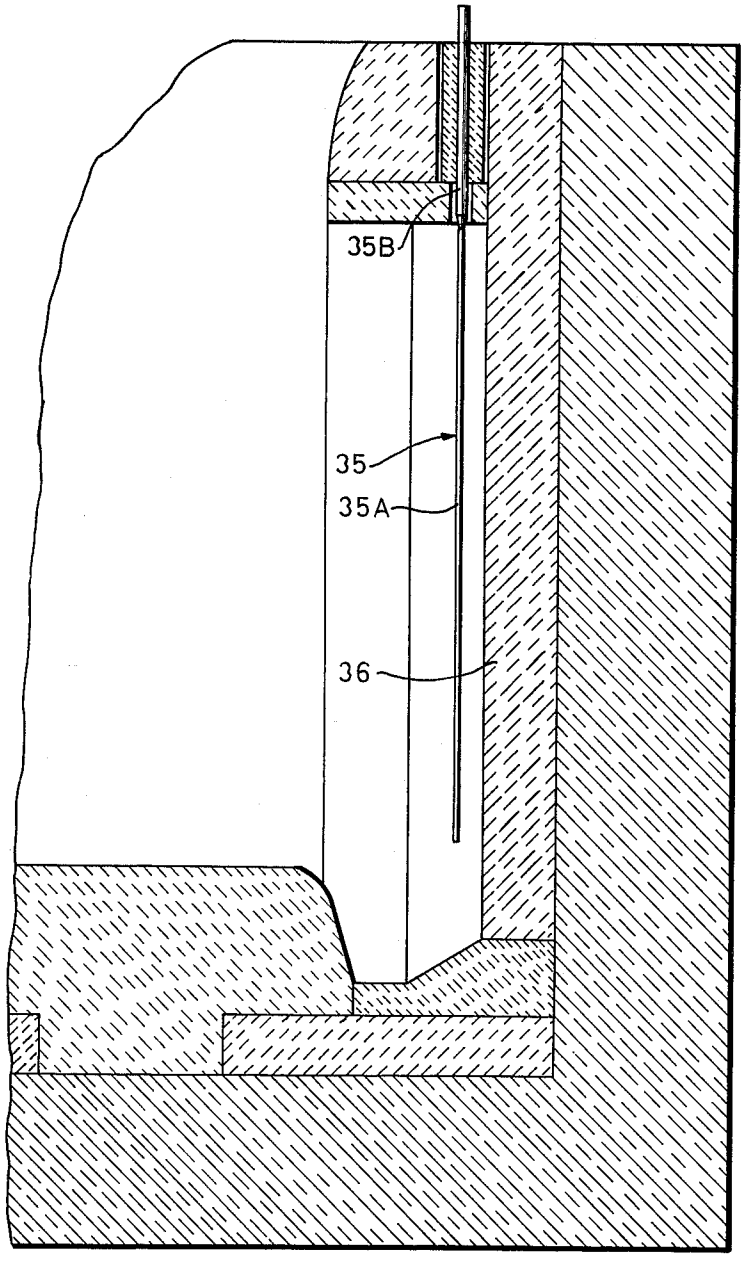


Fig.7

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United States Patent Office 3,092,681 Patented June 4, 1963

3,092,681 ELECTRIC RESISTANCE FURNACES AND THE LIKE

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Claims priority, application Sweden Sept. 22, 1958
2 Claims. (Cl. 13—22)

The present invention relates to an electric resistance furnace and particularly the invention relates to a soaking pit furnace for the thermal treatment in the air of steel. It is not new to heat soaking pit furnaces electrically. For instance, an electrically heated soaking pit furnace is known in which channels are provided in the furnace chamber to receive strings of petrol coke. Heavy carbon electrodes connect the ends of these strings to a source of current having a low voltage in comparison with the effect and the strings become glowing when a high current is applied. For this purpose currents having a magnitude of 3000 A. or 4000 A. and even up to 7000 A. are required.

While glowing, the coke strings of such a furnace are, of course, consumed by oxidation and, therefore, they must be carefully watched and replenished, when required. Often it is to be reckoned with that the petrol coke strings must be replenished several times a week or, even, daily.

Of course, it is necessary in an electrically heated furnace of the above-mentioned kind to have single-phase connections for each petrol coke string. It is customary to use only one or in certain cases two petrol coke strings in each furnace, and therefore the electric net will be asymmetrically loaded which, in certain cases, involves rather a great problem. Another problem that is of even greater importance and—because of the necessary single-phase connection of each coke string—is unavoidable also in furnaces with three coke strings so that an at least substantially symmetric load of the net is permitted, consists in that the electric resistance of the coke strings varies very much owing to the consumption by oxidation, as mentioned above. Therefore, it is necessary to use regulating transformers, i.e. transformers that may be changed over during operation, to keep the effect of the furnace constant. Each coke string must then be fed by a separate regulating transformer, as it is necessary to have a separate regulating possibility for each coke string. Such single-phase transformers are expensive and involve also other drawbacks in this connection, as is known by those skilled in the art.

Besides the problem of watching and replenishing the coke strings and the problem of the high price of the source of current, two further problems occur in connection with furnaces of the above-mentioned kind, which make them appear less satisfactory. One of these problems, which is particularly noticeable in soaking pit furnaces having several pits disposed in a row, is incident of the fact that the coke strings extend through all the pits. This requires an even effect along the whole string and if, on some occasion, one or more pits should not be charged, there is a risk for overheating the walls and the vault of the furnace at a given effect necessary for obtaining a sufficient heat in the pits charged. If, on the other hand, the effect is reduced to avoid such a risk of overheating, there is, instead, the risk of insufficient heat in the pits charged. The second problem, which is closely related to the one just mentioned, consists in that, at the regularly required cleanings and services, i.e. particularly the removal of slags in the form of scalings from ingots, for instance, and the checking of the whole petrol coke strings, it is necessary to work with a rather high effect in the whole furnace until the last ingot has been withdrawn, before the furnace may be switched off for cooling. This means that the furnace is badly utilized in the last period before the maintenance works. In this context it should be mentioned that, if a fault occurs in the petrol coke strings, it is generally necessary to switch off the whole furnace for cooling, which means a long period of waiting, before any adjustment is possible.

For furnaces intended for higher temperatures than 1000° C. and in particular for temperatures above 1400° C., is has been proposed to use resistor elements manufactured by a powder metallurgical method and composed mainly of heat resistant silicides. Primarily, molybdenum disilicide, $MoSi_2$, with possible remainders of oxides, carbides or borides is used, in which case, besides molybdenum, one or more of the elements Ti, Zr, Hf, V, Nb, Ta, Cr and W may be used for the metal atom. When such resistor elements are heated to high temperatures, the action of oxygen of air causes a superficial layer of silicon dioxide to be developed thereon, which becomes plastic at the high sintering temperature during the manufacture and forms a gas tight skin that prevents any further oxidation of the interior of the element, when used. Elements of the just mentioned kind eliminate most of the above mentioned problems with coke string heating sources.

However, when elements of this kind are used in furnaces in which blocks or ingots, preferably of steel, are heated to such high temperatures that most kinds of steel scale off, there arises the problem that such exfoliated particles are thrown out from the surface of the ingots or float around in the furnace chamber as fine dust. The fine particles impinging on the elements may damage the protective layer of silicon dioxide by adhering to and reacting with the layer, and thereby the protective action thereof is often very much reduced. The result of this phenomenon is a reduction of the useful life time of the elements, and therefore it is desirable to eliminate the detrimental effect of the scaling off of the ingots.

Also, in the thermal treatment of other goods, such as glass, ceramic and chemicals, or even from the bricks of the furnace, particles detrimental to such silicide containing elements may be formed.

The main object of the present invention is to solve the above recited problems.

The invention will be described in more detail below with reference to the accompanying drawings which show a number of embodiments.

FIGURE 1 shows a vertical longitudinal section through a portion of a soaking pit furnace;

FIGURE 2 is a horizontal section corresponding to FIG. 1;

FIGURE 3 shows a cross section through the furnace in FIG. 1;

FIGURE 4 shows a vertical section through a portion of a soaking pit furnace in which the elements are inserted through the furnace wall;

FIGURE 5 shows a section along the line V—V in FIG. 4;

FIGURE 6 shows an element in diagrammatic perspective;

FIGURE 7 shows a modification of the soaking pit furnace according to FIG. 4.

The soaking pit furnace shown in FIGS. 1–3 comprises two juxtaposed rows of heating pits **20**, each row containing e.g. ten pits so that the charging capacity amounts to twenty ingots. The furnace is especially intended for heating ingots to rolling temperature, the operating temperature preferably amounting to about 1300° C. The ingots are introduced from above into the heating pits which, for this purpose, are open at the top and each closed by a heavy cover **21**. These covers **21** may be lifted and moved aside by means of a traverse **22**, FIGS. 1 and 3.

This traverse runs on rails along the furnace and is provided with two lifting means 23 and 24, i.e. one for each row of covers 21. The ingots—not shown—are placed in the heating pits on supports 25 cast of some suitable material.

For the electrical heating the invention uses a great number of resistor elements 26 which are introduced into the furnace chamber independently of each other and in such a way that they may be replaced separately from the outside while the furnace is in operation. In the embodiment shown, the resistor elements 26 consist of two parallel and slightly spaced lead in electrodes 26A extending through a common hole in the wall of the furnace and a substantially hairpin-shaped glow zone portion 26B wholly or for the greater part consisting of molybdenum disilicide, $MoSi_2$, which depends along the inner side of the furnace wall. This arrangement of the elements involves several advantages which will be explained in detail below.

As no current supply bars or connections between the elements are provided at the inner side of the furnace walls, vertical webs 27, 28 may be placed between the glow zone portions of the elements to prevent mechanical damage to the glow zones.

The resistor elements of the furnace according to the invention may be connected in the manner most suitable in view of the construction of the furnace. For instance, it is possible to connect the elements 26 in groups each comprising four juxtaposed heating pits 20, and each such group of elements being controlled separately. The elements of each group may be interconnected as desired according to the voltage of the source of current and the dimensions of the elements. As the resistance value of the elements is constant during the operation—contrary to that obtained when using petrol coke strings—no regulating transformer is required. An ordinary transformer is sufficient and the furnace temperature can be controlled by simply switching on and off the elements of the group in question by means of contactors or the like. Further, it is apparent that it is not necessary to control all the groups of elements in the same manner, for which reason the heating pits of each group may be adjusted to the temperature desired at the moment without considering the conditions of the other groups of heating pits. This ensures an economy of operation in every respect.

Elements of the kind mentioned above require a low starting voltage. However, as each group of elements contains several elements, this presents no problem in that the elements can be connected in series to obtain the desired voltage drop, as is easily seen.

The heating of a soaking pit furnace by means of the elements as disclosed above constitutes a considerable improvement over the prior art and involves per se a great progress when it is desired to obtain a more or less continuous operation of furnaces of the kind mentioned. However, in the operation of a soaking pit furnace of this kind, a considerable amount of slag containing i.e. scalings and surface particles exfoliated from the ingots during the heating collects on the bottom of the furnace. This slag may cause disturbances in the operation after some time, by short-circuiting the elements or the like, for instance. This means—even if the elements are intact—that it might become necessary to switch off the furnace and let it cool off to make it possible to remove the slag.

In the furnace according to the invention, this drawback is eliminated in that the supports on the bottom of the furnace are provided on elevated steps 29 around which rather deep slag receiving pockets 30 are formed, which are accessible from the exterior through slag removing openings 31 provided in the furnace walls. These openings are normally closed by stones 32 of a heat resistant material as well as by means of suitable doors 33. As apparent from FIG. 2, it is possible to let two channels from adjoining heat pits converge outwardly, thus being accessible through a common door 33. In this way the furnace may be relieved of slag at any desired time during the operation so that the furnace may be better utilized. As apparent from FIGS. 1 and 3, the elements 26 are not extended down to the bottom of the furnace owing, of course, to the problem of slag formation.

It should be mentioned that the heating of the ingots in the furnace according to the invention occurs by radiation, although the elements of several heating pits are disposed along one wall only. Owing to the extremely high temperature level in the furnace, however, a temperature equalization takes place in such a way that also e.g. the supporting intermediate wall 34 between the two rows of heating pits serves as a radiating surface.

In the furnace according to FIG. 4, electrical elements 35 having the shape of a hairpin or substantially the shape of a hairpin are inserted through the wall 36 of the furnace, the glow zone portion 35A of the elements depending substantially vertically along the inner side of the furnace wall 36 and the two lead in electrodes 35B projecting through the wall of the furnace.

Preferably, the elements consist substantially of molybdenum disilicide, $MoSi_2$, which renders possible an operating temperature of as much as 1600–1700° C. In the embodiment shown, the elements are bent at the portion where the glow zone portion 35A merges with the lead in electrodes 35B so as to include an angle of about 120°. However, the elements may be bent more or less, e.g. perpendicularly, or they may be arched. As shown in FIG. 7, the elements may also be arranged depending vertically from the vault of the furnace.

The wall of the furnace is provided with inlet openings 37 larger than strictly necesary for the insertion of the elements. The inlet openings 37 are partly filled with a casting mass 38 in which one or more juxtaposed inlet holes 39 for the elements are provided. The lead in electrodes 35B of the elements rest in notches 40 in the casting mass 38 and in the refractory bricks 41. Other refractory bricks 42 and 43 are placed on the lead in electrodes and the refractory bricks 41 and the mass 38, respectively. Shoulders 38A of the mass 38 prevent the innermost bricks 42 of each element from sliding off into the furnace. The elements may easily be withdrawn after release of the contact pieces 44 and the element holders 45 and removal of the refractory bricks 41, 42 and 43. When inserting the elements, the sealing and securing of the elements is effected by fitting the parts mentioned in the reversed order. Of course, the refractory bricks 41, 42 and 43 as well as the design of the mass 38 must be adapted to the shape of the elements in each separate case.

It is clear that, according to the basic principle of the invention, the elements of each of the furnaces mentioned above operate at so high temperatures that the superficial layer of silcon dioxide becomes flowing. Impurities impinging on the elements are, therefore, automatically conveyed to the lower part of the element together with the superficial layer and form small drops that leave the element. Consequently, an automatic cleansing of the elements is obtained.

The above specification describes the invention substantially with reference to the use of elements consisting essentially of molybdenum disilicide, $MoSi_2$. However, it is clear that it also relates to other siliciferous elements, as well as elements of silicon carbide etc., for instance.

Thus, besides $MoSi_2$, the resistor elements may contain other metals or oxides which, on oxidation of the elements, are partly converted into an oxidiferous material that forms a flowable superficial layer on the elements together with SiO_2. The elements may be composed of $MoSi_2$ and a ceramic binding agent which is formed entirely or partly of an easily fusible clay, such as bentonite, for instance, at the sintering of the elements. It is particularly advantageous to use an easily fusible clay

as binding agent for $MoSi_2$, as thereby the protective layer is given such a composition that it may flow off without impeding the protective action against oxidation.

In the above specification, the invention has been described with reference to certain embodiments thereof, but of course it is not restricted thereto, as several modifications and alterations as to details are possible within the scope of the invention.

What I claim is:

1. In a soaking pit furnace for thermal treatment in the air of steel, a furnace chamber, a heating source consisting of elongated, hairpin-shaped resistor elements containing molybdenum disilicide, $MoSi_2$, having the property of producing on their surface a layer containing silicon dioxide when heated to high temperatures, because of the action of the oxygen of the air, said elements each having a glow portion depending vertically into the furnace chamber, and each element having two lead-in electrodes extending to the exterior of the furnace chamber at a short distance from one another through a common opening so that the elements are replaceable individually while the furnace is functioning, the composition and arrangement of the resistor elements being such, that in operation the superficial layer containing silicon dioxide together with oxide particles deposited on the glow zone of the elements after separation from the steel, becomes flowing and under the action of gravity flows slowly downwards along the length of the resistance elements, while a new superficial layer is being continuously formed, the excess simultaneously leaving the elements in the form of drops so that impurities adhered to the surface of the elements are removed.

2. A resistance furnace according to claim 1, wherein the elements depend vertically downwards through the furnace chamber.

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